The Nautic-Astronomical and Universal Calculator. The Mechanical Solving of all Arithmetical Problems, Plane and Spherical Trigonometry, including Terrestrial and Astronomical Navigation. By R. Nelting. Pp. 67. (Hamburg: R. Nelting, 1909.) Price 4 marks.

In many numerical processes there has been too great a tendency on the part of computers to employ more decimal places than are necessary, and to use logarithms where more direct methods would be effective. The introduction of mechanical contrivances for the performance of arithmetical operations has brought the problem of a possibly greater simplification of calculation more to the front, with the result that some neglected resources have been made available. One outcome has been the improvement in accuracy and ingenuity in construction of sliding scales for obtaining an approximate solution of many simple problems. With increased usefulness, however, comes a tendency to increase the number of moving parts and to give greater variety to the system of dividing, but this more complicated mechanism often destroys the simplicity of construction which is one great merit in the sliding scale. Certainly, the invention described by Mr. Nelting does not err on the side of simplicity. The inventor claims for his calculator that it will give the logs. of numbers, with their squares and square roots; the values of trigonometrical functions of sine, tangent, cosecant and cotangent of angles, whether expressed in time or in arc; tables of reciprocals with their squares and square roots. In addition to many other combinations, the scales can be used for facilitating or completely solving problems required in nautical astronomy connected with altitude, longitude, and latitude, with an accuracy sufficient for the purposes of navigation. Unfortunately, we have not had an opportunity of studying the mechanism, and the rules that are given for its use are not easily followed when the necessary constructions cannot be made. Moreover, the description is obscure in many parts.

The Theory of Electric Cables and Networks. By Dr. Alexander Russell. Pp. x+269. (London: A. Constable and Co., Ltd., 1908.) Price 8s. net.

We opened this book expecting to find it filled with the solutions of rather unpractical problems, the solutions, however, being of considerable importance in higher mathematics. We find that it is a very practical treatise which will prove useful to the increasingly numerous class of electrical engineers who deal with distributing networks, their insulation and faults. The last two chapters, on electrical safety valves and lightning conductors, are particularly good. J. P.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* Nature. *No notice is taken of anonymous communications.*]

On the Relation of "Recoil" Phenomena to the Final Radio-active Product of Radium.

In the course of some experiments made by Miss Brooks (Nature, July 21, 1904, vol. lxx., p. 270) on the active deposits from radium, it was found that the active product, radium B, escaped in some manner from a body which had been rendered active in the presence of radium emanation, and was carried at low pressures to the walls of the containing vessel. In his interpretation of this result, Rutherford ("Radio-activity," p. 392) suggests the possibility of the phenomenon being due to a recoil effect rather than to a volatility possessed by the product radium B.

Radium A atoms, in breaking up, are known to emit α particles with a velocity of $1{\cdot}7\times10^9$ cm. per sec., and as the mass of the α particle is 4 (H=1) and that of the radium B atom approximately 200, it is clear from the explosive nature of the disintegration of the radium A atoms that the radium B atoms must be hurled away with a considerable velocity in directions opposite to those in which the α particles are projected.

Recent papers by Otto Hahn and Lise Meitner (*Verh. der deut. phys. Ges.*, xi., Jahr No. 3, and *Phys. Zeit.*, 10 Jahr, p. 81) and by Russ and Makower (Proc. Roy. Soc., No. 5, 553, p. 205, May 6) contain descriptions of experiments which confirm the truth of Rutherford's explanation, and also show that it is possible to isolate the radio-active products, radium A, B, and C, thorium D and actinium X and C, through the agency of this recoil action alone.

Other examples of this recoil phenomenon are also contained in the recent experiments of Debierne (*Le Radium*, April) and in those of Kennedy on the active deposit from actinium (*Physical Review*, May).

In considering these examples of the recoil effect, the question naturally arises of a possible connection between this phenomenon and the final transmutation product of radium. Radium G (polonium) is known to emit α rays, and when deposited on plates of copper, as Logeman and others have shown, to emit also a feeble δ radiation. From the illustrations which have been cited above it seems clear that here also the recoil phenomenon should manifest itself in the projecting from such radium G coated plates of atoms of the final radio-active product.

Evidence of such projection has recently been obtained in the physical laboratory at Toronto by Mr. V. E. Pound. In his experiments an insulated plate of copper, A, approximately 3 sq. cm. in area, which was coated with a deposit of radium G, was placed in a highly exhausted chamber facing a second insulated plate of copper, B. The plate B was joined to an electrometer, and the electrical charges which it acquired under various electric and magnetic fields were observed.

With moderate electric and magnetic fields results similar to those of Logeman, Ewers, Aschkinass, and others were obtained, and from the form of the charging curves which were obtained in such circumstances it was clear that at least three types of radiation were present and exerted an effect of greater or less degree on the charge acquired by the plate B, viz.:—(1) the α rays emitted by plate A; (2) easily absorbed δ rays emitted by plate A; and (3) an easily absorbed secondary radiation emitted by plate B, consisting of negatively charged particles.

With higher magnetic fields, however, an entirely new phenomenon appeared. With such fields, especially when the plate A was charged to an increasingly high positive potential, it was found possible gradually to increase the positive charge acquired by the plate B. As such higher magnetic fields were sufficient to prevent the secondary radiation from leaving the plate B, and the high positive potentials were sufficient to retain the δ radiation on the plate A without affecting the α radiation, it seems evident that the rise in the positive charge acquired by the plate B was due to the existence of a radiation of negatively charged particles from the plate A which had hitherto escaped detection, but which in these experiments were deflected by the magnetic field. When the plate A was neutral or negatively charged, the application of the magnetic field failed to give any indication of the presence of this radiation, but with the application of a potential of 160 or 240 volts (positive) to the plate A it could be readily brought into evidence. It is of interest to see, therefore, that in this case a positive electric field united with a magnetic field was the means by which the radiation was isolated.

The experiments are being continued, and it is too early at present to write more definitely regarding the new radiation. It seems, however, highly probable that this radiation can be attributed to the "rest-atoms" of the active product radium G. The expulsion of an α particle would leave this rest-atom negatively charged. Such rest-atoms would leave the plate in all directions as a stream of negatively charged particles. They would be less pene-

trating than the α particles, and so would escape detection in absorption experiments in gases at ordinary pressures.

If this new radiation consists of the "rest-atom" of radium G, we have in the property that it is projected with high velocity and in that that it carries an electrical charge the means of ascertaining its mass. Such a knowledge would give very definite information regarding the constitution of the final radio-active product of radium, and would also, in addition, furnish a means of checking the accuracy of the now highly authenticated theory by which the various known radio-active products of radium are connected and related.

The existence of this radiation, moreover, would afford a means of ascertaining whether the rest-atoms of radium G are the final products of radium or not, for it should be possible to obtain, through bombardment, a coating of these rest-atoms on a body such as the plate B in the experiments described above. This plate could then be placed in a high vacuum and investigated for the acquisition of an electrical charge. Any gain of charge which it might experience could be taken as proof of the formation of a new product, while the absence of such gain might be taken as evidence that radio-activity had ceased, and that in the rest-atoms of radium G stability is finally attained.

J. C. McLENNAN.

Physical Laboratory, University of Toronto, June 7.

Molecular Effusion and Transpiration.

ONE of Maxwell's most famous laws is his law on the distribution of velocities, to the effect that all the molecules of a gas do not possess the same velocity, but that the various velocities of the molecules group about a certain average velocity Ω in a definite way, which was further theoretically determined by Maxwell. This law has not, however, hitherto been directly proved by experiment, and I am therefore of opinion that the following may be of some interest to English readers.

The flow of the gases through very small apertures and narrow tubes at ordinary pressure has been investigated by Graham and several others, and definite laws (the effusion and transpiration laws) which apply to these flows have been found. My experiments now show that if the area of the aperture or the transverse section of the tube are small compared with the mean free path of the gas molecules, then other and still simpler laws than those mentioned will apply, and that these laws are easily deducible from the kinetic gas theory and Maxwell's law on the distribution of velocities. Detailed reports of the experiments have been published in *Annalen der Physik*, Bd. xxviii., 1909.

Molecular Effusion.—According to the kinetic gas theory, the number of molecular shocks which the surface-area A of a wall receives during a second from the surrounding gas is equal to $\frac{1}{4}$N AΩ, where N is the number of gas molecules in each cm.^{3} and Ω the average velocity of the molecules. If there is an aperture in the wall having an area A, and if N′ and N″ are the numbers of gas molecules at each side of the wall respectively, $\frac{1}{4}A\Omega(N'-N'')$ more molecules are flying through the aperture in the course of a second in one direction than in the other. Taking m as the weight of each molecule, the weight G of the gas flowing through the aperture during a second would be

$$G=\tfrac{1}{4}A\Omega(N'm-N''m)=\tfrac{1}{4}A\Omega(\rho'-\rho'')=\tfrac{1}{4}A\Omega\rho_1(p'-p''),$$

where ρ is specific gravity, p the pressure, and ρ_1 the specific gravity of the gas at the pressure 1 dyn./cm.^{2} and the temperature of the gas. According to Maxwell's law on the distribution of velocities we get $\Omega=\sqrt{\frac{8}{\pi\rho_1}}$, which gives

$$G=\frac{A}{\sqrt{2\pi}}\cdot\sqrt{\rho_1}\cdot(p'-p'').$$

The fact that the weight found is proportional to, and therefore the volume of gas is inversely proportional to, the square root of the specific gravity has been shown by numbers of experiments made by different investigators; but the factor $\frac{A}{\sqrt{2\pi}}$ and the proportionality with the difference of pressure have not been experimentally found earlier, and they prove to apply only when the mean free path is more than about ten times greater than the diameter of the aperture. By a series of experiments with an aperture in a plate of platinum 0·0025 mm. thick, where the area of the aperture was found by means of the microscope to measure $5{\cdot}21\pm0{\cdot}16$ millionth square centimetres, I found the following proportions between the observed quantity and that computed from the above formula:—hydrogen, 0·978; oxygen, 0·981.

From another aperture, the area of which was $66{\cdot}0\times10^{-6}$ cm.^{2}, the following proportions were found:—hydrogen, 1·021; oxygen, 1·038.

Consequently, the difference between theory and observation is 2 per cent. to 3 per cent., which is considered chiefly to be due to the difficulty of making an exact determination of the areas of such small apertures. If by computation of the above formula no attention had been paid to Maxwell's law on the distribution of velocities, and all the molecules had been considered as moving with the same velocity, we should have taken $\Omega=\sqrt{\frac{3}{\rho_1}}$, the effect of which would be that the computed values would become 8·6 per cent. greater than if we used Maxwell's formula, and the difference between theory and experiment caused thereby could scarcely be explained as an error of observation.

By the above-mentioned experiments the pressures were measured with McLeod's manometer, and the determinations of pressures checked each other, so that there was not found the slightest indication of a real or apparent deviation from the laws of Mariotte and Gay-Lussac.

The formula may be used for determination of $p'-p''$ if A and G are measured for some gas. In this way I have made an experimental determination of the maximum pressure of mercury vapour at 0°, and a series of higher temperatures up to 46°. By 0° the pressure was found to be 0·0001846 mm. mercury pressure. From the measurements I have obtained the following formula for the vapour-pressure p, given in mm. mercury (common system of logarithms, T = absolute temperature):—

$$\log p=10{\cdot}5724-0{\cdot}847\log T-3342{\cdot}26/T.$$

The mean deviation between the values derived from this formula and those observed amounts to 0·003 of the value, which shows that the constants of the formula are determined with fairly great accuracy. It is seen that if the formula is used for extrapolation to pressures at higher temperatures we get now positive, now negative deviations from the determinations made by other experimentalists, so that the formula in reality expresses the vapour-pressure of the mercury up to 880°, which is the highest temperature at which Cailletet and his collaborators have determined the pressure. At this temperature he found a pressure of 162 atmospheres where my formula gives 158 atmospheres.

Molecular Transpiration.—A series of experiments I have made with relation to the flow of gases through narrow tubes at low pressures has also confirmed Maxwell's law on the distribution of velocities. The calculation of the quantity of gas flowing through the tubes cannot, however, be made without using a new theory for the reflection of gas molecules from a wall. My theory for this reflection of gas molecules, which has been fully confirmed by the experiments, is as follows:—

A gas molecule meeting a wall is reflected in a direction which is absolutely independent of the direction in which it is moving against the wall, and a great number of molecules, meeting a wall, are reflected in every direction according to Lambert's law (the cos. law on the emission of light from a hot body). Consequently, the gas molecules may be considered as having strayed into the wall or as having been absorbed by it, to be emitted afterwards therefrom, provided that the gas and the wall have the same temperature. The calculation of the quantity of gas streaming through the tube is quite simple, though, however, too extensive to be given here. For the weight of gas flowing through the tube in each second we get the following expression:—